A STUDY OF ABSORPTION LINES OF POTASSIUM VAPOUR UNDER VARYING CONDITIONS OF TEMPERATURE AND PRESSURE

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Plate II

ABSTRACT. The absorption spectra of potassium vapour under varying conditions of temperature and pressure have been studied using a hydrogen continuum as the background. It is observed that the number of absorption lines increases with the increase in the partial vapour pressure.

INTRODUCTION

Professor Saha remarked in 1924: "There seems to be at present a wide divergence of views regarding the magnitude of pressure in the reversing layers of stars." From the existing record of the number of lines in the Fraunhofer spectrum in case of hydrogen, sodium, magnesium and calcium, he postulated that the pressure in the outer layers of the photosphere was such that the orbits beyond the sixth were rarely developed. He also considered the well-known formula $n \propto (T/P)^{\frac{1}{6}}$

where n is the order number of the lines developed,
T is the temperature, and
P is the vapour pressure,

and concluded that the number of lines would increase as the pressure diminished. Datta and Roy (1930) made an attempt to have experimental support of Saha's hypothesis. But their source of continuous radiation was not so satisfactory as is available at present. Hence experiments with potassium in nitrogen gas, using hydrogen continuum as the background, have been undertaken by us to see the behaviour of the absorption lines of the element potassium, under varying conditions of temperature and pressure.

EXPERIMENT

The scheme of the arrangement is indicated in the annexed diagram where S is a small quartz spectrograph, C is a hydrogen discharge tube (Fig. 1) for a continuous source both supplied by Adam Hilger, Ltd. TT is a metal tube in which a metal cell G open at both ends containing potassium was introduced.

The tube TT was first covered with a single layer of asbestos paper and then a piece of nichrome wire was wound round it. Finally, a sheet of asbestos paper was rolled round the tube so that there might not be any fluctuation in temperature due to external disturbances. The rest of the diagram is self-explanatory. M is a mercury manometer, A1, A2, A3, A4, are vacuum stopcocks and D is a gas washing bottle partly filled with strong sulphuric acid. Nitrogen was selected to be introduced whenever any change in the total pressure in the observation tube TT was desired, as any combination of alkali metals with nitrogen is unknown. The flow of nitrogen from the cylinder had to be regulated before connecting the cylinder to the pressure

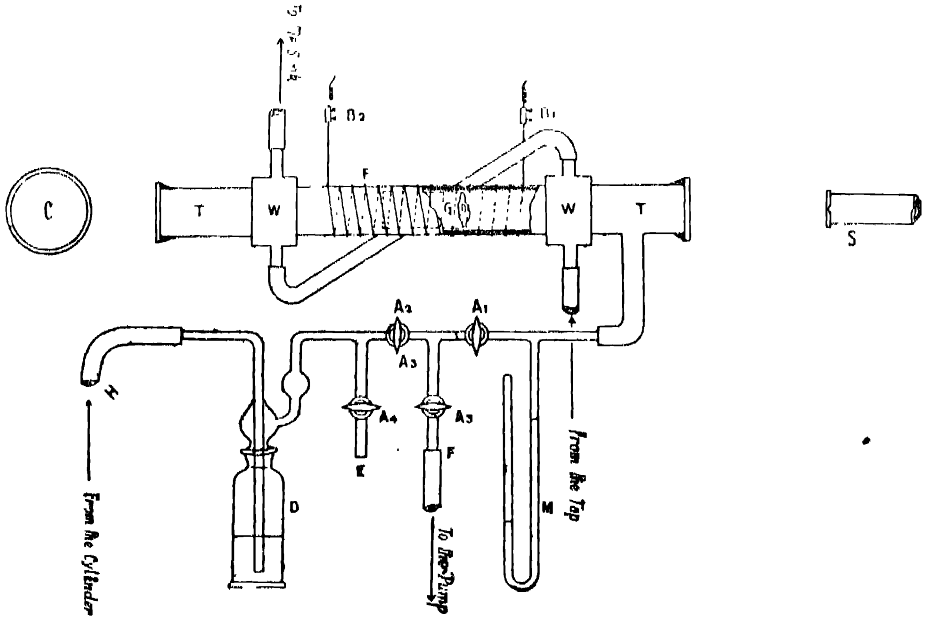

FIG. 1

tube at H. The end F was connected to a suitable suction pump and, before heating, the tube TT was thoroughly evacuated by running the pump for a long time and the stopcock A1 was kept closed for nearly 24 hours. There was practically no change in the readings of the manometer within that period. Photographs were taken only when temperatures desired became stationary. Though with varying temperature vapour pressure of potassium was altered within the observation tube TT, its indication could not be detected in the manometer. So we had to make an estimate of the partial pressures of the vapour of potassium by calculating the pressure by the empirical formla (Johnston *et al*, 1928) $\log_{10} p = -52.23\ A/T + B$, where p is the pressure in mm. and T is the temperature on absolute scale. The values of A and B for potassium are 84.9 and 7.183.

Alterations in the total pressure could only be read in the manometer when nitrogen gas was introduced, *i.e.*, only when the pressure-communicating medium was present.

TABLE I

Spectrum	Temperature	Partial vapour pressure of potassium	Total pressure in mm.	Number of lines developed	Visual estimate of intensity of the line $\lambda=4045.6$
a	388°C	3 mm.	0.1 mm.	0	0
			30.0	3	2
b			66.0	8	4
			106.0	3	6
c			140.0	7	6
			260.0	7	8
d			400.0	7	8
			680.0	7	10
e	433°C	21 mm.	0.1	6	1
			30.0	10	1
f			66.0	10	3
			106.0	10	3
g			143.0	10	5
			263.0	10	5
h			400.0	10	8
			760.0	10	10
i			850.0	10	10
			940.0	10	10
j	545°C	58 mm.	0.1	10	1
			30.0	13	2
k			66.0	13	4
			106.0	13	7
l			143.0	13	8
			263.0	13	8
m			400.0	14	8
			760.0	14	8
n			860.0	14	8
o	695°C	400 mm.	0.1	10	very faint
			30.0	13	1
p			120.0	13	2
q			220.0	13	3
			300.0	14	4
r			390.0	14	4
			480.0	14	5
s			615.0	14	5
t			680.0	14	5
			760.0	15	6
u			106.0	15	5
			140.0	15	5

RESULTS

The results of the experiment are entered in Table I. The figures in sixth column give the variation of the intensity of the line $^2S_{\frac{1}{2}} - (2)\ ^2P_{\frac{1}{2}, \frac{3}{2}}$, *i.e.*, $\lambda = 4045.6$Å. The intensity of other absorption lines varies in exactly the same way. From the figures it is quite apparent that intensity of each line increases with total pressure. The rate of increase in intensity is greater at low pressures than at high pressures. Again we notice in column 5 that the number of lines also increases with total pressure. But here we also notice that after a certain value of total pressure is reached the number of absorption lines becomes almost constant. An inspection of column 2 and 5 read with figures in column 3 shows that the number of absorption lines at high partial vapour pressure is greater than at low partial vapour pressure. Thus number of lines at partial vapour pressure 3 mm. varies from 0 to 7, at partial vapour pressure 21 mm. varies from 6 to 10, at partial vapour pressure 58 mm. varies from 10 to 14 and at partial vapour pressure 400 mm. varies from 10 to 15. From these we conclude that greater number of absorption lines can be seen when the temperature, *i.e.*, when partial pressure of the vapour of the metal is increased. It is also clear that partial vapour pressure of the metal which depends upon the temperature of the tube has greater influence on the number of absorption lines than the total pressure. The effect of total pressure on the intensity of the lines, however, cannot be doubted.

It is also to be noted that two sharp absorption lines on both sides of the line $^2S_{\frac{1}{2}} - (3)\ ^2P_{\frac{1}{2}, \frac{3}{2}}$, *i.e.*, $\lambda = 3447{\cdot}2$Å were clearly seen in the negative taken at temperature 695°C, though their presence is not indicated in the print marked u (Plate II).

More detailed study of the main problem of this paper together with that of the lines referred to in the last paragraph is considered necessary before attempting to give any explanation of the phenomena.

Our thanks are due to Professor S. P. Prasad for giving us every facility in conducting this piece of work.

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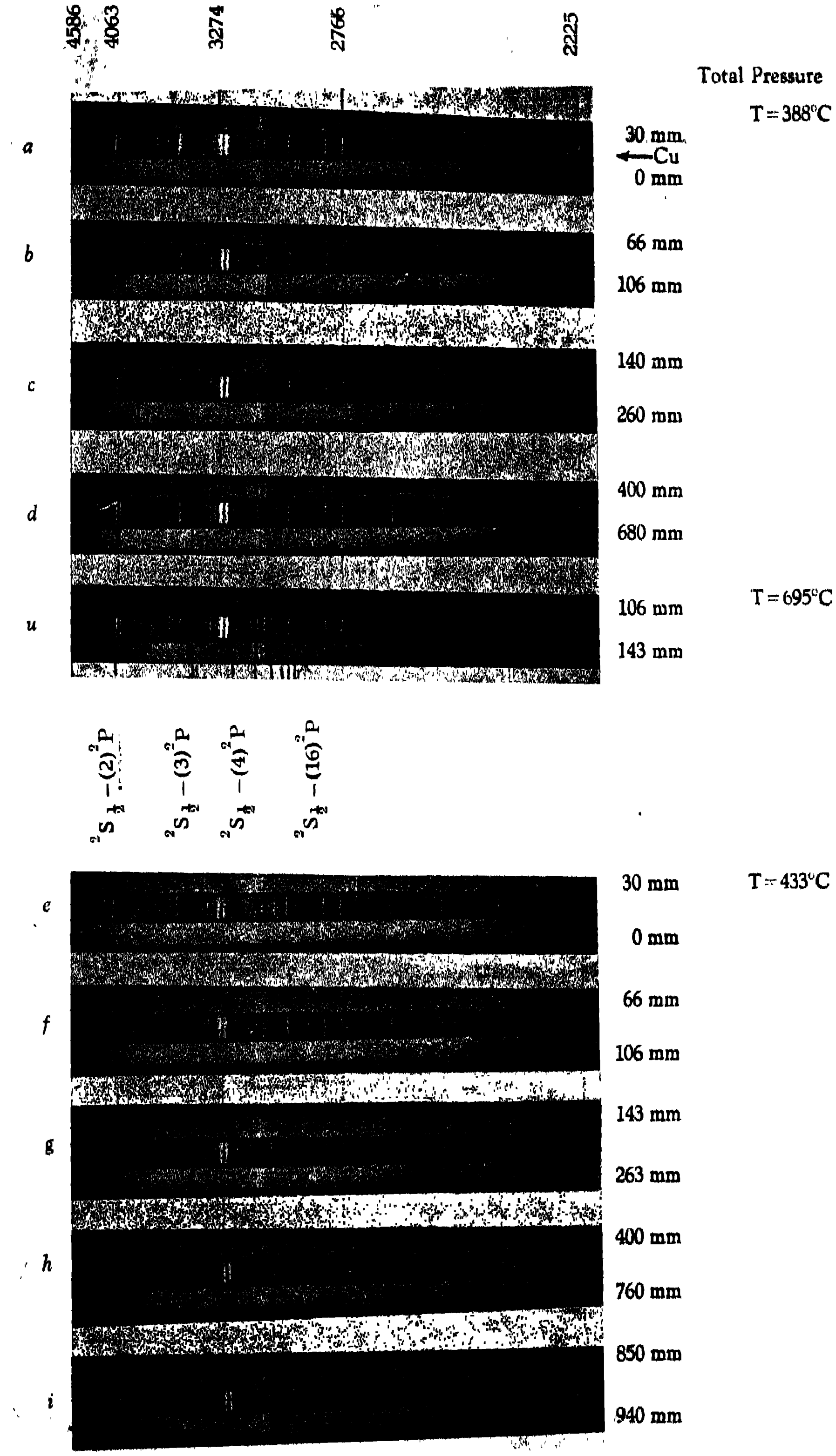
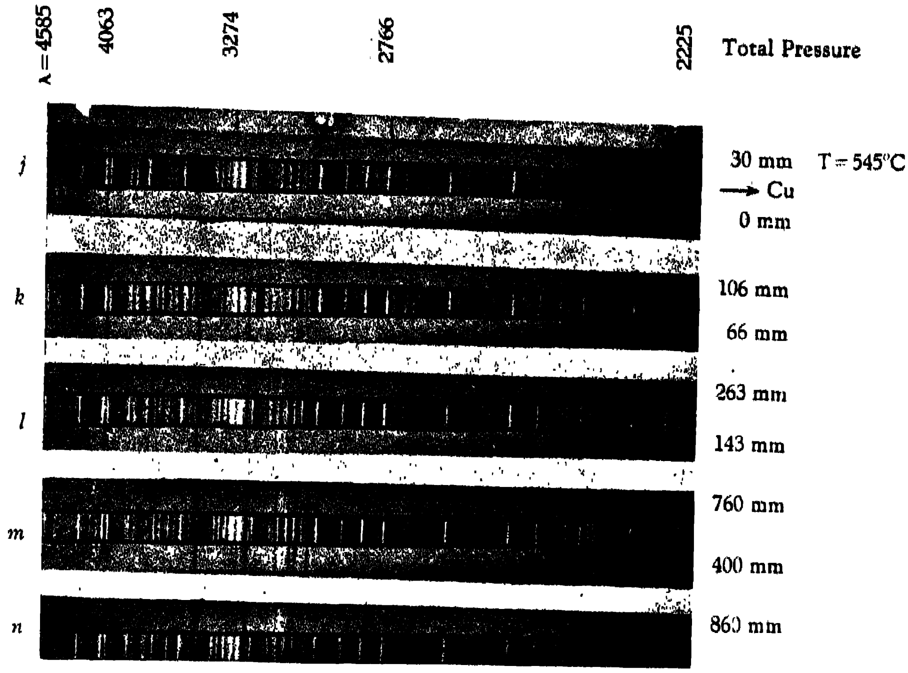
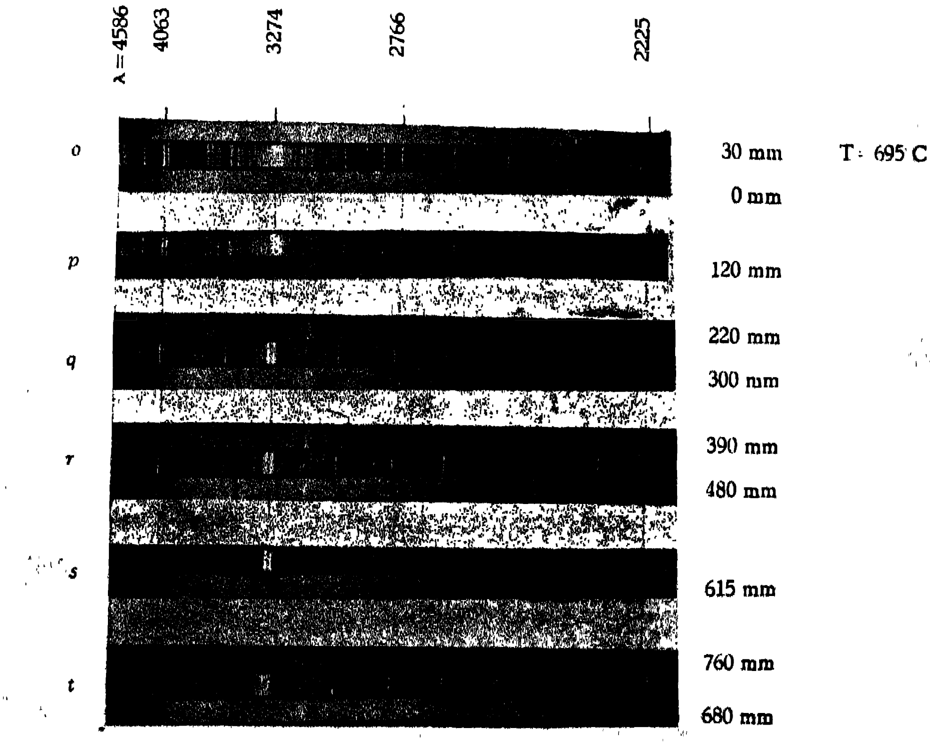

4586
4063
3274
2766
2225
Total Pressure
T = 388°C
a
30 mm.
←Cu
0 mm
b
66 mm
106 mm
c
140 mm
260 mm
d
400 mm
680 mm
u
T = 695°C
106 mm
143 mm
$^2S_{\frac{1}{2}}-(2)^2P$
$^2S_{\frac{1}{2}}-(3)^2P$
$^2S_{\frac{1}{2}}-(4)^2P$
$^2S_{\frac{1}{2}}-(16)^2P$
e
30 mm
T = 433°C
0 mm
f
66 mm
106 mm
g
143 mm
263 mm
h
400 mm
760 mm
i
850 mm
940 mm

PLATE II B


λ=4585
4063
3274
2766
2225
Total Pressure
j
k
l
m
n
30 mm
→ Cu
0 mm
T = 545°C
106 mm
66 mm
263 mm
143 mm
760 mm
400 mm
860 mm


λ=4586
4063
3274
2766
2225
o
p
q
r
s
t
30 mm
0 mm
T = 695°C
120 mm
220 mm
300 mm
390 mm
480 mm
615 mm
760 mm
680 mm